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Experimental Engineering. Vol. ii. Testing and Strength of Materials of Construction. By W. C. Popplewell, M.Sc. Pp. viii+404. (Manchester: Scientific Publishing Company, 1901.) Price 10*s.* 6*d.* net.

THERE is no doubt that the most striking feature in the increased provision of means for the scientific training of engineers during the last quarter of a century has been the great development of laboratories equipped for experiment and research in all branches of engineering. While as yet there is no general agreement as to the best avenue to the engineering profession, it is universally admitted that such a training as is possible in a well-arranged laboratory can be made a most valuable adjunct to any system of instruction or apprenticeship. This development alone has created a field for a series of text-books such as that of which the book before us is the second volume, while the fact that it is also intended to meet the needs of the large class regularly engaged in what is known as "commercial" testing serves to widen its scope, without in any way diminishing its value for more strictly educational purposes. The book contains a large amount of useful matter, collected with much discrimination from a great variety of sources, and we have little hesitation in saying that it will in very great measure meet the needs to which we have referred.

In his introduction, Mr. Popplewell explains that he has included a chapter on the mechanics of bodies under test loads, not with the view of instructing the novice in the fundamental parts of the subject, but simply in order to explain briefly the leading principles involved, and to record the formulæ to be afterwards used. Such brief explanations of general principles, however, are almost always unsatisfactory in themselves; it so often happens that in arriving at a simple formula the important matters are those which are omitted, so that the subject is presented to the student in a garb of spurious simplicity. Again, the student, allured by the brevity of such explanations, is strongly tempted to confine his investigation of the principles to the explanatory chapter and to overlook the author's disclaimer. The results of this tendency are only too apparent in the bald proofs so familiar to every examiner in the subject. And further, apart from its expressed limitations, Mr. Popplewell's chapter of theory is in itself in some respects open to criticism.

It is, for instance, important that the measure of a "strain" should be a number representing what may be called the strain-ratio, so that for any elastic deformation we have the simple relation

$$\text{strain} = \frac{\text{stress}}{\text{modulus}},$$

the modulus being the stress which would produce unit strain. We find, however, that while "strain" is correctly defined on p. 14, the very next page presents us with the unhappy equation

$$\frac{\text{stress applied}}{\text{modulus of elasticity}} = \frac{\text{amount of strain}}{\text{original length of the prism}}$$

The discussion, again, of the relation between E and G, the moduli of elasticity and of rigidity respectively, is cumbersome and might be much simplified, and although it is pointed out that the result (that G is to E as 2 is to 5) depends on assuming that Poisson's ratio has the value 4, which is only partially justified by experiment, this result is quoted on p. 216 as having been deduced in the earlier chapter from purely theoretical considerations. Generally speaking there is a marked lack of elegance about Mr. Popplewell's mathematics; special instances of his cumbersome style may be found on p. 40, and again on p. 160.

On the other hand, he has done well to call special attention to the difference between the twisting moment in a bar in which, the state being entirely elastic, the stress is proportional to the radius, and that in a bar in which, the plastic state having been reached, the stress may be regarded as uniform over the section, a distinction which is sometimes lost sight of in reducing and comparing the results of observation.

The second chapter, a long one, is devoted to the description of testing machines, and the comparison of the advantages and disadvantages of the various types of large machines in general use will be found of great value not only by the works manager or teacher who may require a machine to suit special conditions, but also by the intelligent student, who is only too apt to regard the particular machine, on which it may be his lot to work, as embodying all the virtues, or it may be all the vices, of its kind. Many of the illustrations, particularly the diagrammatic views of different types of machines, are very good, and for a few more of these we could well spare the half-dozen or so of photographs, which have in most cases been taken in a bad light and have all suffered in reproduction. It is a pity to burden a text-book with general views which can be found, reproduced in much better style, in the makers' catalogues.

It were vain to attempt anything like an exhaustive description of the various measuring appliances now in use, as it seems to be a point of honour for each laboratory to design a special type, but Mr. Popplewell gives a short and sufficient account of the more familiar extensometers and gauges. More perhaps might have been said of optical methods of measurement, particularly of appliances depending on the principle of the optical lever, which is now largely used in many laboratories, or embodying a delicate spirit level, of which one instance only, Prof. Unwin's extensometer, is described.

Special chapters are devoted to descriptions of the methods of carrying out various tests in tension, compression, bending and torsion, and of recording and reducing the results, and these chapters are well done. In the account of bending tests we notice no reference to the bending of long rods of small section. Even if these tests are not of importance from the commercial point of view, they are of value in the laboratory from the simplicity of the apparatus and the ease with which the properties of different materials can be compared, and from the fact that elastic displacements large enough to be accurately measured with micrometer eyepieces can be used.

Several torsion machines are described, and the difficulty of obtaining a pure twisting couple is pointed out. It is the case, however, that in many of the torsional machines in ordinary use the method of measuring the

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torsional deformation is not sufficiently accurate to justify elaborate precautions against bending moments, although it is not difficult to devise quite simple apparatus for making these angular measurements. These simpler means are somewhat overlooked by Mr. Popplewell, but an excellent account is given of the more elaborate and accurate instrument designed by Mr. Coker.

We are glad to find that our author, while describing several of the standard forms of apparatus for taking autographic records, is alive to the fact that these records are of secondary importance so far as the determination of the properties of the material is concerned, although undoubtedly of great use in exhibiting the nature of these properties. In educational testing especially, as indeed in all laboratory work, there is a danger of fostering too great reliance on autographic records, and the supreme value of first-hand observations cannot be too strongly insisted on.

It must suffice here to mention that the sections of the book which deal with the tests of ropes, chains, struts and so on are sufficient for their purpose, that there is a useful account of cement testing, although perhaps enough weight is not allowed to the personal factor in mixing, and that tests of the other materials of building construction are also briefly dealt with. Some account is also given of the effect of varying conditions, such as temperature, annealing, and bending, on the properties of metals. The effect of repeated stress and of reversed stress is dealt with in Chapter xi., and it would add considerably to the practical value of this chapter if a description of some of the standard pieces of apparatus used in making these tests were included. The account of timber testing is somewhat brief, but the general course of such tests is described and some standard determinations are quoted.

In his final chapter Mr. Popplewell has collected and tabulated a large number of determinations of what he calls the strength properties of the various materials considered, and this chapter, which seems both comprehensive and up to date, will undoubtedly be much used for reference by all who have occasion to consider these properties. He also adds a bibliography of books and memoirs.

We find no reference to the microscopic investigation of the structure of metals, a subject which has so much advanced of late years. The subject, indeed, demands a volume to itself, and at present perhaps is more in the province of the metallurgist than in that of the engineer, but its application to the investigation of flaws in structural parts has already given it a practical bearing which ought not to be overlooked.

Throughout the whole volume the need of occasional calibration of any testing machine in ordinary use is not indicated, nor is any description of the methods usually adopted in carrying out such a calibration given. This is a matter of such importance from a practical point of view that we must attribute the omission to inadvertence, and it will no doubt be rectified in another edition. On the whole, notwithstanding the few omissions and defects to which we have thought it necessary to call attention, we heartily commend the book to all who have to do either with the commercial testing of materials or with the management of the testing departments of engineering laboratories.

A NEW SURVEYING INSTRUMENT.

Der Hammer-Fennel'sche Tachymeter-Theodolit und die Tachymeter-kippregel zur unmittelbaren Lattenablesung von Horizontaldistanz und Höhenunterschied. Von Dr. E. Hammer, Professor an der K. Technischen Hochschule in Stuttgart. Mit 16 Figuren im Text und 2 Lithographierten Tafeln. Pp. 52. (Stuttgart: Konrad Wittwer, 1901.)

PROF. HAMMER has long occupied himself with the problem of constructing an instrument which should give the surveyor the necessary data for plotting his work with the least possible difficulty. Indeed, his numerous references to his previous work, and to the criticisms he has from time to time offered on the work of others, make his introduction not a little difficult to read. But, since the history of his work connected with tacheometers is set out with true German completeness, it may be valuable to anyone who is working on similar lines. In 1893 the author began to solve the following problem: to devise a tacheometer-theodolite, by which at one operation and without reading an altitude circle the observer could determine both the horizontal distance and the difference of altitude of a selected spot from the instrument. This problem the author now claims to have satisfactorily solved, and the instrument is on the market; but notwithstanding this long preparation we gather that several small improvements touching the arrangement of the microscopes and the general mounting of the instrument are still contemplated.

The optical part of the instrument consists of a so-called Porro object-glass, in which two lenses are kept at a constant distance from each other. The principal object-glass has a focal length of 350 mm., and the second lens, placed at a distance of 340 mm., 220 mm., giving to the entire system a focal length of 335 mm. The focussing is effected by moving the object-glass, and the eyepiece views a diagram of peculiar construction on which the effectiveness of the instrument depends. No compass or altitude circle is furnished with the tacheometer, but these can be added if it is desired to use the instrument as a transit theodolite or for other purposes. Instead of an altitude circle, a prism is placed at the side of the telescope above the axis, in connection with which is a carefully constructed diagram, arranged to a scale, by which can be shown the amount of tilting given to the telescope. A second prism placed behind the ocular throws an image of the diagram into the field of view, and as the telescope is moved up or down the diagram is moved to the right or left of the field, thus causing the lines of the diagram indicating the amount of inclination to cut the vertical wire in the eyepiece at a different place. The diagram and mechanical adjustments are so arranged that by multiplying the observed displacement of the line from the zero by 20, the difference of altitude in metres will result, while another displacement multiplied by 100 gives the distance. Very great care seems to have been bestowed on the construction of the field diagram on which the accuracy of the instrument must much depend. The correctness of the coefficient could no doubt be effectually checked by the measurement of known distances and of differences of altitude. Some little inconvenience, it would seem, must arise from the

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